United States Patent Office

3,330,706

Patented July 11, 1967

3,330,706

NITROSTARCH EXPLOSIVES CONTAINING SLOWLY HYDRATABLE GUAR GUM

George L. Griffith, Coopersburg, Pa., assignor to Trojan Powder Company, Allentown, Pa., a corporation of New York

No Drawing. Filed Feb. 8, 1966, Ser. No. 525,841
16 Claims. (Cl. 149—38)

ABSTRACT OF THE DISCLOSURE

Nitrostarch explosive compositions are provided containing moist nitrostarch and a guar gum which has a rate of hydration such in the presence of sufficient water at 25° C. to form a 1% solution, at least one hour is required to form a solution having a viscosity of 2000 cps. The guar gum is effective as a latent sensitizer to absorb moisture from and sensitize the moist nitrostarch. The explosive composition in addition to the nitrostarch can include one or more inorganic oxidizer salts such as ammonium nitrate, one or more fuels including particulate metal fuel and carbonaceous fuels, as well as additional explosive sensitizers.

This invention relates to nitrostarch explosive compositions, and more particularly, to explosive compositions based on wet or damp nitrostarch as the principal explosive sensitizer, together with guar gum as a latent sensitizer for the nitrostarch.

It is well known that nitrostarch is extremely sensitive to handle when dry, but is relatively nonsensitive and nonhazardous when wet. As usually manufactured, the product subsequent to nitration, purification and washing, is obtained in a wet or moist condition. The moisture content is reduced by centrifuging, but after centrifuging, the damp nitrostarch still contains approximately 22% of water. The damp material can be dried by heating, but this produces a dangerously sensitive dry powder. Accordingly, it has been the practice, as described and claimed in U.S. Patent No. 2,860,041, patented Nov. 11, 1958, to George L. Griffith and David G. Samuel, Jr., to blend the nitrostarch while wet with the other ingredients of the composition, and to combine the nitrostarch with a latent sensitizing agent which is capable of absorbing the water contained in the nitrostarch, and thus slowly sensitizing the explosive composition containing the same.

The result of this is an explosive composition containing realtively dry nitrostarch and a wet latent sensitizing agent which has absorbed possibly its capacity for moisture. Inasmuch as damp nitrostarch contains approximately 22% of water a considerable proportion of moisture is absorbed by the sensitizing agent, and consequently, relatively large amounts of the sensitizing agent may be required. In fact, the ratio of the sensitizing agent to moisture may range from about 7 to about 80 parts of the agent for each 100 parts of water.

A number of latent sensitizing agents have been disclosed in Patent No. 2,860,041. These include locust bean gum karaya gum, and sodium carboxymethyl cellulose in solid powdered form. Of these materials, the sodium carboxymethyl cellulose has been by far the most satisfactory.

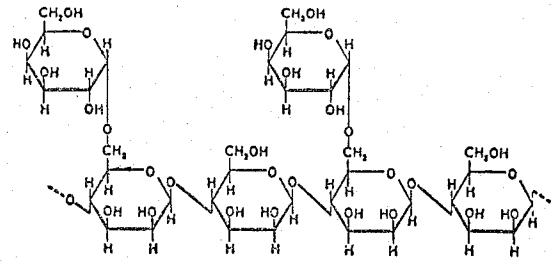
Materials rather closely related to these chemically have surprisingly been found to be ineffective. The various starchs, guar gum, methyl cellulose and silica gel are disclosed in Patent No. 2,860,041 as unsatisfactory. It was not known at that time, and it is still not known, what is responsible for the effectiveness of an operative sensitizing agent. Locust bean gum and guar gum, for

example, are rather closely related chemically, and yet the guar gum materials available at that time were found to act very differently in the presence of damp or wet nitrostarch.

In accordance with the invention, explosive compositions based on nitrostarch as the principal explosive sensitizer are provided, including as a latent sensitizing agent a guar gum having a low rate of hydration by water. The guar gums in accordance with the invention, unlike the guar gums previously known, due to this property are capable of functioning as latent sensitizers for moist nitrostarch. When combined therewith, they absorb moisture therefrom, and in due time bring the nitrostarch into a relatively dry, sensitive condition.

The guar molecule is chemically described as a galactomannan, essentially a straight-chain polymannose branched at quite regular intervals with single membered galactose units, usually on alternate mannose units. The mannose units are linked to each other by means of β-1,4-glycosidic linkages, and the galactose branching is accomplished through an α-1,6-linkage.

The structure of guar gum has been established as follows:



Guar gum is thus classifiable as a high molecular weight carbohydrate polymer or polysaccharide, made of many mannose and galactose units linked together in the pattern described above. The long straight-chain nature of this molecule, combined with its regular side branching, is unique among the natural colloids, and is probably responsible for the differences which have been noted in U.S. Patent No. 2,860,041 between guar gum and locust bean gum, a polymannose of a closely similar structure.

The hydroxyl groups attached to the saccharide units and the hydroxyl group attached to the CH_2OH group are chemically reactive, and can be reacted with chemical reagents capable of reacting with alcohols. They can, for example, be acylated by reaction with the corresponding acyl chlorides, or with aldehydes, or with acids. They can also be reacted with boric acid and borates, and with other metals and metal compounds, such as aluminum, calcium and chromium. Such modifications introduce useful variations in physical and chemical properties.

Guar gum will hydrate and swell in the presence of water, and the rate of hydration and the rate of swelling are both characteristic of a given species. As the guar gum hydrates and swells, it dissolves, and the viscosity of the aqueous medium in which it is placed begins to increase, indicating that the guar gum is going into solution, and is directly proportional to the amount of guar gum present in solution. Accordingly, the rate of increase in viscosity of the solution with time is a measure of the rate of hydration of the guar gum.

Guar gum in general tends to absorb water rather slowly. When the particles of guar gum are contacted with water they swell to form a gel. The volume of the particle may increase several times before dissolution becomes significant. The smaller particles can absorb water wholly rather rapidly, and then begin to dissolve. If the particle is large enough, however, a surface gel or skin can form, which slows penetration of water into the interior, and

slows down absorption of water considerably thereafter. It is apparent, therefore, that a large or coarse particle will require a much longer period to absorb its total capacity for absorbed water than a small or fine particle. For this reason, it is thought, coarse particles are effective in the invention, whereas fine particles absorb water too quickly to be effective.

Chemically modified guar gum is effective if, in the same way, the rate of absorption of water can be slowed down. This can be effected by chemical modification of the sort that results in gel formation in the presence of water. The formation of a gel on the surface of the particles wet with water slows down the rate of absorption of water into the interior, so that the total capacity of the paricle for water is not reached until a longer contact time has elapsed.

Dissolution follows gel formation and it is for this reason that rate of increase of viscosity is a good, although indirect, measure of the rate of hydration, i.e., of water absorption of the guar gum, and enables one from the rate of hydration to predit effectiveness of the invention. Dissolution in water does not of course result in the compositions of the invention, which are solid formulations, but water absorption by the guar gum is repsonsible for sensitization of the nitrostarch.

It has been determined that guar gum which is effective as a latent sensitizer in the moist nitrostarch-based explosive compositions of the invention has a rate of hydration such that, in the presence of sufficient water at 25° C. to form a 1% solution, at least one hour is required for the solution to reach a viscosity of 2000 cps. The preferred guar gum in accordance with the invention require at least one hour to reach a viscosity of 1000 cps. at this temperature, and ninety minutes or longer to reach a viscosity of 1750 cps. In contrast, usual guar gums have an appreciably faster rate of hydration, and reach 2000 cps. at 25° C. in less than forty minutes.

The rate of hydration and swelling of guar gum can be varied by appropriate modification of the physical condition of the guar gum particles, or by chemical modification of the guar molecule, or by both. Inasmuch as the rate of hydration is inversely proportional to the particle size, the desired slow rate of hydration in many cases can be obtained by providing the gum in the form of coarse particles. The guar gum particles should have a mesh size (U.S. Standard Sieve) of at least about 230, and preferably within the range from about 120 to about 35. Particles larger than 35 mesh usually but not always have a too slow rate of hydration, and if they do, are unsatisfactory.

Rate of hydration also can be slowed by chemical modification of the guar molecule. Guar has three free hydroxyl groups in each mannose and galactose unit, and these as indicated are chemically reactive, and will react with acids, acid chlorides, and other reagents, as well as metal cations. The degree of substitution can thus vary from 0 to 3.

Many polyvalent cations, including calcium, aluminum, and chromium, will insolubilize guar gum. Reaction of the guar molecule with a smaller amount of the cation than will insolubilize the guar gum can result in a slowing of its rate of hydration. Borate ions also are capable of insolubilizing guar gum, and for strong structural aqueous gels under alkaline conditions. A slightly borated guar gum can accordingly be prepared to have the desired slow hydration rate.

Guar also forms a series of guar ether and guar ester derivatives analogous to cellulose ethers, including alkyl ethers, such as methyl, ethyl, propyl, isopropyl, butyl, and amyl, hydroxyalkyl ethers, such as hydroxyethyl, hydroxypropyl and hydroxybutyl, mixed alkyl hydroxyalkyl ethers, such as ethyl hydroxyethyl, methyl hydroxyethyl, ethyl hydroxypropyl, and propyl hydroxypropyl; ionic ethers such as carboxymethyl and carboxyethyl; and also analogous to cellulose esters, such as the acetate,

propionate, butyrate, and mixed esters such as acetate-propionate and acetate-butyrate, and ionic esters such as the sulfate. These usually have a degree of substitution of from about 0.4 to about 1.7.

Suitable preparatory procedures are known to the art, and are described, for example, in U.S. Patent No. 3,222,-185, patented Dec. 7, 1965, to Yueh. For example the carboxymethyl derivative may be suitably prepared by dispersing guar gum in an ice cold 45% solution of sodium hydroxide at a gum concentration of approximately 30 grams per 100 ml. of base. The thus dispersed gum is allowed to stand for approximately 30 minutes under ice cold temperature conditions after which there is slowly added with stirring a freshly prepared aqueous 75% solution of chloroacetic acid. Approximately 40 ml. of chloroacetic acid solution is added for each 100 ml. of NaOH-guar gum solution. The temperature of the resulting mixture is then raised approximately to 75° C., and the mixture allowed to reset for about 30 minutes. The reaction mixture, which is in a gelled state, is then cooled, subdivided, and neutralized with acetic acid. The product is precipitated and washed with methanol until the methanol wash solution is colorless. The product is then dried and grounded to a powder form. This same technique can be used, with variations which will be apparent to those skilled in the art, to prepare other alkyl derivatives such as the ethyl and propyl varieties by substituting the appropriate halo alkyl acid for chloroacetic acid.

The hydroxyalkyl derivatives, such as hydroxy ethyl guar gum, may be prepared by dispersing guar gum in a sodium hydroxide as prescribed above for carboxymethylation, after which the temperature is raised to 50° C. and one part of chloroethanol for each part of guar solution is added, with stirring. After about one hour the reaction mixture is neutralized, the modified gum separated by alcohol precipitation, and then washed and purified with methanol, dried and ground to a suitable particle size range.

Another type of modification by reaction of the hydroxyl groups that is applicable to guar gum by analogy to cellulose is described in U.S. Patents Nos. 2,879,268 to Jullander, dated Mar. 24, 1959, and 3,072,635 to Menkart et al., dated Jan. 8, 1963, and involves reacting the guar gum with a dialdehyde such as glyoxal, or epichlorhydrin, or a dicarboxylic acid, or diepoxide, or other polyfunctional reagent reactive with hydroxyl groups. The functional groups should not be separated by more than about six carbon atoms, for best results.

The modification of the guar gum, either chemically, or physically, or both, in order to modify the rate of hydration thereof, forms no part of the instant invention. The above description shows that those skilled in the guar gum art are well aware of various techniques that can be used for this purpose.

The essential ingredients of the explosive compositions in accordance with the invention are damp, moist, or wet nitrostarch and the guar gum of slow water hydration characteristics. In addition to the essential ingredients, there can also be incorporated an inorganic oxidizer, one or more fuels, and optionally, additional sensitizing explosives.

The inorganic oxidizer can include any inorganic nitrate, chlorate or perchlorate. Ammonium nitrate, ammonium chlorate, and ammonium perchlorate, the nitrates, chlorates and perchlorates of the alkali and alkaline earth metals, such as sodium nitrate, potassium nitrate, barium nitrate, strontium nitrate, calcium nitrate, sodium chlorate, potassium chlorate, barium chlorate, sodium perchlorate, potassium perchlorate, barium perchlorate, and calcium perchlorate are exemplary inorganic nitrates, chlorates and perchlorates.

Mixtures of nitrates, chlorates and perchlorates, of nitrates and chlorates, of nitrates and perchlorates, and

of chlorates and perchlorates, can be used. Ammonium nitrate is the preferred oxidizers, and sodium nitrate is the preferred nitrate for use with ammonium nitrate.

The relative proportions of the inorganic oxidizers are important for good explosive shock and power. The ammonium oxidizer is employed in a proportion within the range from about 50 to about 100%, and the other oxidizer or oxidizers in a proportion within the range from 0 to about 50% of the total oxidizer. For optimum power, the proportions are from 80 to 90% ammonium oxidizer, and from 10 to 20% other oxidizer or oxidizers. An oxidizer mixture of approximately 80 to 90% ammonium oxidizer and 10 to 20% of the other oxidizer or oxidizers is in most cases the best. The particular proportions of oxidizers selected within these ranges will depend upon the sensitivity and explosive effect desired, and these in turn are dependent upon the particular nitrate or chlorate or perchlorate used.

The inorganic oxidizer can be fine, coarse, or a blend of fine and coarse material. Mill and prill inorganic oxidizers are quite satisfactory. For best results, the sodium oxidizer and ammonium oxidizer should be fine-grained.

The nitrostarch is the principal sensitizing explosive used with the inorganic oxidizer. If desired, additional sensitizing explosive can be employed, alone or in admixture. Liquid explosives can be used, such as, for example, the nitric esters or organic nitrates and the nitroamines, for example, trinitroglycerine, glyceryl trinitrate, methyl nitrate, ethyl nitrate, n-propyl nitrate, and isopropyl nitrate, dinitroglycerine, nitroglycide, tetranitrodiglycerine, nitroglycol, trinitrophenoxyethyl nitrate, 2,4,6-trinitrophenyl nitroaminoethyl nitrate (pentryl), hexanitrodiphenyl aminoethyl nitrate, trimethylene glycol dinitrate, propylene glycol dinitrate, and trimethylolethane trinitrate.

Solid sensitizing explosives that can be employed include trinitrotoluene, pentaerythritol tetranitrate, dipentaerythritol hexanitrate, mannitol hexanitrate, sorbitol hexanitrate, sucrose octanitrate, pentolite (an equal parts by weight mixture of pentaerythritol tetranitrate and trinitrotoluene), Cyclonite (RDX, cyclotrimethylene trinitramine), nitrocellulose, Composition B (a mixture of up to 60% RDX, up to 40% TNT, and 1 to 4% wax), Cyclotol (Composition B without the wax), tetryl, and smokeless powder, such as carbine ball powder.

Nitrostarch in combination with a mixture of ammonium nitrate and other nitrate is preferred, because it gives the greatest explosive effect.

The relative proportions of oxidizer and sensitizing explosive will depend upon the sensitivity and explosive shock wave desired, and these again are dependent upon the particular nitrate and sensitizer. These proportions are not critical in any way. From about 15 to about 30% sensitizing explosive, and from about 50 to about 70% oxidizer, give the best results. At amounts beyond 40%, the sensitizing effect falls off, and is no longer proportional to the amount of sensitizing explosive added, and therefore amounts beyond 40% are not usually used.

Sensitizing explosives in any particle size can be used. They can, for example, be fine, coarse or a blend of fine and coarse material. Some materials, such as nitrostarch, are commercially available as very finely-divided powders, and so also is trinitrotoluene. Such available materials are employed to advantage, because in most cases they tend to produce compositions having a greater explosive effect.

In addition to the inorganic oxidizer and sensitizing explosive, the explosive compositions of the invention can include a fuel. A particulate metal fuel, for example, flake aluminum, atomized aluminum, ferrophosphorus and ferrosilicon, is in many cases preferred. A metal fuel usually comprises from about 0.5% to about 30% of the composition preferably from 0.5 to 5% in the case of aluminum.

In addition to or in place of the metal fuel, a carbonaceous fuel can be included as an optional ingredient, such as powdered coal, petroleum oil, coke dust, charcoal, bagasse, dextrin, starch, wood meal, flour, bran, pecan meal, and similar nut shell meals. A carbonaceous fuel when present will usually comprise from about 0.5 to about 30% of the mixture.

Mixtures of metal and carbonaceous fuels can be used, if desired.

An antacid or other stabilizing material, such as zinc oxide, calcium carbonate, aluminum oxide and sodium carbonate, can also be added. Such ingredients will comprise from about 0.3 to about 2% of the mixture.

The amount of slow hydrating guar gum that is employed depends upon the moisture content of the composition. As indicated previously, the nitrostarch that is employed is as obtained after centrifuging or other moisture-separation technique, containing the moisture that is not removed in this manner. Such a damp nitrostarch normally contains up to approximately 25% of water. In addition to this water, which is wholly absorbed in the nitrostarch, a small amount of water can be added to aid in the mixing of the dry ingredients. For this purpose, only small amounts of water are usually required, ranging up to approximately 15% by weight of the total composition. Thus, the water content of the mixture will usually be within the range from about 15 to about 40% by weight. The amount of water will normally not be less than about 15% by weight of the nitrostarch, since less than this will not impart the desired insensitivity during manufacture and packaging of the explosive. More than about 40% by weight of the mixture is unnecessary, and merely means that more slow hydrating guar gum must be used to absorb the extra water.

The amount of slowly hydrating guar gum accordingly is within the range from about 5% to about 50% by weight of the moisture content of the composition. The amount of guar gum chosen within this range will determine the sensitivity of the finished explosive. If maximum sensitization is desired, the amount of guar gum should be at the upper portion of the range, and if a composition of lesser sensitivity is desired, then the amount of guar gum can be in the lower to middle portion of the range.

The composition as initially prepared is as insensitive as the nitrostarch employed in its preparation. With time, the sensitivity of the composition increases, as the slow hydrating guar gum absorbs the water present. Normally, maximum sensitivity is obtained within from about five hours to about one week from the time of mixture, depending upon the amount of water present, and the rate of hydration characteristic of the guar gum that is employed.

The explosive composition of the invention is readily prepared by simple mixing of the ingredients. The composition as formulated is normally dry-appearing granules, even when more water is present than can be absorbed by the nitrostarch. Because of this, the composition can be prepared in a conventional dry mixer and screened, using screens having a mesh size of four openings per square inch, and even smaller. A ribbon mixer or a single shaft paddle mixer can also be employed. The solid materials usually are mixed first, and then the damp nitrostarch and slow hydrating guar gum can be added with further stirring. The resulting mix is screened in the usual way.

The explosive composition can then be filled into open end cartridges, using conventional extrusion equipment, or other filling equipment, to produce the final explosive package.

The cartridge container can be formed of any container material. Heavy cardboard is inexpensive and available

in sufficient thickness of wall, and is therefore preferred. The cartridge container can also be formed of plastic and cellulosic materials, such as polyethylene, ethyl cellulose, cellulose acetate, cellulose acetate-propionate, cellulose acetatebutyrate, polypropylene, polytetrafluoroethylene, nylon, polyvinyl chloride, polystyrene, and polyvinylidene chloride, and nonferrous metals, such as tin, copper and aluminum. Fibrous materials, such as wood, paper and cardboard can be used as such, or, if desired, can be impregnated with a synthetic resin to improve strength and water resistance.

The explosives of the invention can be fired according to their formulation by an ordinary blasting cap or with the aid of a booster charge. The size cap and the amount of booster charge required, if any, depends, of course, upon the amount of sensitivity of the explosive mixture.

The following examples, in the opinion of the inventor, represent preferred embodiments of his invention.

The slow hydrating guar gum used in the examples was evaluated for rate of hydration and swelling in water by the following test. A 1% solution of the guar gum was prepared by stirring the gum into water by hand. Viscosities were taken at ten minute intervals at 25° C., using a Brookfield Syncro-Lectric Viscosimeter, Model RVF, at 20 r.p.m. The viscosity characteristic taken under these conditions is set out for each guar gum used.

Examples 1 to 4

	Parts by Weight				
	Control	Example 1	Example 2	Example 3	Example 4
Nitrostarch, wet (23% H_2O)	26.00	26.00	26.00	26.00	26.00
Ammonium nitrate (grained mill)	61.80	61.80	61.80	61.80	61.80
Sodium nitrate	9.10	9.10	9.10	9.10	9.10
Zinc oxide	0.30	0.30	0.30	0.30	0.30
Aluminum (flake)	2.30	2.30	2.30	2.30	2.30
Oil No. 5	0.50	0.50	0.50	0.50	0.50
Guar gum:					
Jaguar:					
537-Z-5		2.00			
537-Z-6			2.00		
537-Z-7				2.00	
537-Z-A					2.00
Total weight	100.00	102.00	102.00	102.00	102.00

Time	Rate of Hydration of Guar Gum			
	Jaguar 537Z5 (cps.)	Jaguar 537Z6 (cps.)	Jaguar 537Z7 (cps.)	Jaguar 537Z7A (cps.)
5 minutes	26	8	8	6
15 minutes	335	25	30	6
30 minutes	1,090	170	160	14
60 minutes	1,700	480	480	26
120 minutes	2,190	992	1,140	70

The compositions were prepared by mixing the dry materials for two minutes in a paddle mixer until a homogeneous solid blend had been obtained. There were then added the wet nitrostarch and the guar gum, and mixing was continued for a further two minutes until the nitrostarch and guar gum had been homogeneously dispersed in the mixture. The blends were then screened, and filled in 1¼ x 8 inch cartridges. "D"-sensitivities were determined one, three and seven days after mixing, in order to determine any changes that occurred due to the absorption of moisture by the guar gum from the wet nitrostarch. The following data were taken:

"D" Sensitivity	Control	Example			
		1	2	3	4
After 1 day	3 g. PETN*	D-6 cap	No. 5 cap	No. 6 cap	No. 6 cap.
After 3 days	3 g. PETN*	do	do	do	No. 5 cap.
After 1 week		T-8 cap	D-6 cap	D-6 cap	D-6 cap.
Stick weight (g.)	219	209	207	207	205.

*Failed to detonate with 3 g.

The improvement in sensitivity obtainable with the compositions of Examples 1 to 4, inclusive, including the guar gum was greatly improved, as compared to a control composition without the guar gum.

Examples 5 and 6

A group of nitrostarch-based powdered explosive compositions was prepared, according to the following formulations:

	Parts by Weight		
	Control	Example 5	Example 6
Nitrostarch, wet (23 percent H_2O)	26.00	26.00	26.00
Ammonium nitrate (grained mill)	61.80	61.80	61.80
Sodium nitrate	9.10	9.10	9.10
Zinc oxide	0.30	0.30	0.30
Aluminum, flake	2.30	2.30	2.30
Oil No. 5	0.50	0.50	0.50
Guar gum:			
Jaguar:			
537Z-8		2.00	
580-R			2.00
Total weight	100.00	102.00	102.00

Time	Rate of Hydration of Guar Gum	
	Jaguar 537Z-8 (cps.)	Jaguar 580-R (cps.)
5 minutes	5 to 8	90
15 minutes	5 to 8	500
30 minutes	15	1,100
60 minutes	60	1,900
120 minutes	265	2,800

The compositions were prepared by mixing the dry materials for two minutes in a paddle mixer until a homogeneous solid blend had been obtained. There were then added the wet nitrostarch and the guar gum, and mixing was continued for a further two minutes until the nitrostarch and guar gum had been homogeneously dispersed in the mixture. The blends were then screened, and

filled in 1¼ x 8 inch cartridges. "D"-sensitivities were determined one, three and seven days after mixing, in order to determine any changes that occurred due to the absorption of moisture by the guar gum from the wet nitrostarch. The following data were taken:

"D" Sensitivity	Control	Example 5	Example 6
After 1 day	3 g. PETN	D-6 cap.	D-6 cap.
After 3 days	3 g. PETN	D-6 cap.	No. 16 cap.
After 1 week		D-6 cap.	No. 16 cap.
Stick Weight (g.)	219	213	215.

There is thus a considerable improvement in sensitivity obtainable with the compositions of Examples 5 and 6, including the guar gum, as compared to the control compositions without any sensitizing agent.

Examples 7 to 10

A group of nitrostarch-based powdered explosive compositions was prepared, according to the following formulations:

	Control	Example 7	Example 8	Example 9	Example 10
Nitrostarch, wet (23 percent H_2O)	26.00	26.00	26.00	26.00	26.00
Ammonium nitrate (grained mill)	61.80	61.80	61.80	61.80	61.80
Sodium nitrate	9.10	9.10	9.10	9.10	9.10
Zinc oxide	0.30	0.30	0.30	0.30	0 30
Aluminum (flake)	2.30	2.30	2 3.0	2.30	2.30
Oil No. 5	0.50	0.50	0.50	0.50	0.50
Guar gum:					
Jaguar:					
537-Z-8		2.00			
537-Z-10			2.00		
537-Z-11				2.00	
537-Z-12					2.00
Total weight	100.00	102.00	102.00	102.00	102.00

Time	Rate of Hydration of Guar Gum			
	Jaguar 537-Z-8 (cps.)	Jaguar 537-Z-10 (cps.)	Jaguar 537-Z-11 (cps.)	Jaguar 537-Z-12 (cps.)
5 minutes	5 to 8	25	10	8
15 minutes	5 to 8	276	19	9
30 minutes	15	752	44	20
60 minutes	60	1,288	100	22
120 minutes	265	1,764	182	41

The compositions were prepared by mixing the dry materials for two minutes in a paddle mixer until a homogeneous solid blend had been obtained. There was then added the wet nitrostarch, and mixing was continued for a further two minutes until the nitrostarch had been homogeneously dispersed in the mixture. The blends were then screened, and filled in 1¼ x 8 inch cartridges. "D"-sensitivities were determined one, three, and seven days after mixing, in order to determine any changes that occurred due to the absorption of moisture by the guar gum from the wet nitrostarch. The following data were taken:

"D" Sensitivity	Control	Example 7	Example 8	Example 9	Example 10
After 1 day	No. 8 cap.	No. 3 cap.	No. 3 cap.	No. 3 cap.	No. 2 cap.
After 3 days	No. 10 cap.	No. 3 cap.	No. 4 cap.	No. 4 cap.	No. 4 cap.
After 1 week	No. 14 cap.	No. 3 cap.	No. 5 cap.	No. 3 cap.	No. 2 cap.
Stick weight (g.)	206	203	204	203	202.

The improvement in sensitivity obtainable with the compositions of Examples 7 to 10, inclusive, including the guar gum, as compared to the control containing no latent sensitizer is very evident.

All percentages in the specification and claims are by weight and are by weight of the entire composition unless otherwise indicated.

Having regard to the foregoing disclosure, the following is claimed as the inventive and patentable embodiments thereof:

1. An explosive composition based on moist nitrostarch as the principal explosive sensitizer, comprising moist nitrostarch and a guar gum effective as a latent sensitizer to absorb moisture from and sensitize the moist nitrostarch, the guar gum being characterized by a rate of hydration such that in the presence of sufficient water at 25° C. to form a 1% solution, at least one hour is required to form a solution having a viscosity of 2,000 cps.

2. A nitrostarch explosive composition in accordance with claim 1, in which the guar gum is in the form of coarse particles of between about 35 and about 350 mesh in size.

3. A nitrostarch explosive composition in accordance with claim 1 comprising an inorganic oxidizer salt.

4. A nitrostarch explosive composition in accordance with claim 3, in which the inorganic oxidizer salt is an ammonium oxidizer.

5. A nitrostarch composition in accordance with claim 4 containing, in addition to ammonium oxidizer salt, a minor proportion of another inorganic oxidizer salt.

6. A nitrostarch explosive composition in accordance with claim 3, in which the inorganic oxidizer salt is ammonium nitrate.

7. A nitrostarch explosive composition in accordance with claim 3 comprising from about 15 to about 40% moist nitrostarch and from about 50 to about 70% inorganic oxidizer salt.

8. A nitrostarch explosive composition in accordance with claim 3 which also includes a carbonaceous and/or metal fuel.

9. A nitrostarch explosive composition in accordance with claim 8 in which the fuel is a particulate metal fuel.

10. A nitrostarch explosive composition in accordance with claim 8 in which the fuel is a carbonaceous fuel.

11. A nitrostarch explosive composition in accordance with claim 1 in which the composition contains up to 40% water and the guar gum is present in an amount of within the range of about 5 up to about 50% by weight of the water content of the composition.

12. A nitrostarch explosive composition consisting essentially of from about 15 to about 40% of moist nitrostarch containing from about 4 to 25% water, an amount of within the range from about 0.2% to about 5% of a slowly hydrating guar gum sufficient to sensitize the nitrostarch by absorption of water contained therein, the guar gum being characterized by a rate of hydration in the presence of sufficient water at 25° C. to form a 1% solution such that at least one hour is required to form a solution having a viscosity of 2,000 cps., from about 50 to about 70% ammonium nitrate, and from about 0.5 to about 30% of a carbonaceous and/or metal fuel.

13. A nitrostarch explosive composition in accordance with claim 12 comprising an alkali metal nitrate in substitution for a minor proportion by weight of the ammonium nitrate.

14. A nitrostarch explosive composition in accordance with claim 12 in which the fuel is particulate aluminum.

15. A nitrostarch explosive composition in accordance with claim 12 in which the guar gum has a rate of hydration such that at least one hour is required to form a solution having a viscosity of 1,000 cps. at 25° C.

16. A nitrostahch explosive composition in accordance with claim 12 comprising a supplemental organic sensitizing explosive in substitution for a minor proportion of the nitrostarch.

References Cited

UNITED STATES PATENTS

2,860,041	11/1958	Griffith et al.	149—108 X
2,968,541	1/1961	Wilt et al.	149—108
3,083,127	3/1963	Griffith et al.	149—59 X
3,153,606	10/1964	Breza et al.	149—44 X
3,180,773	4/1965	Wells et al.	149—58
3,201,291	8/1965	Schmidt	149—44 X
3,222,232	12/1965	Schwoyer	149—38 X
3,235,423	2/1966	Ferguson	149—38
3,238,074	3/1966	Griffith et al.	149—38 X
3,249,477	5/1966	Clay et al.	149—44 X
3,261,732	7/1966	Eilo	149—38

CARL D. QUARFORTH, *Primary Examiner.*

BENJAMIN R. PADGETT, *Examiner.*

S. J. LECHERT, JR., *Assistant Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,330,706 July 11, 1967

George L. Griffith

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 50, for "realtively" read -- relatively --; line 61, for "gum" read -- gum, --; column 3, line 15, for "paricle" read -- particle --; line 21, for "predit" read -- predict --; line 24, for "repsonsible" read -- responsible --; column 4, line 19, for "reset" read -- react --; column 5, line 2, for "oxidizers" read -- oxidizer --; columns 9 and 10, in the table, fourth column, line 5 thereof, for "23.0" read -- 2.30 --; column 12, line 9, for "nitrostahch" read -- nitrostarch --.

Signed and sealed this 18th day of June 1968.

(SEAL)

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

EDWARD J. BRENNER

Commissioner of Patents